Emergency and Disaster Response to Chemical Releases

Technician Level Training

29 CFR 1910.120(q)

Module 4

Monitoring

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Acronyms Used in This Module

CAM	Chemical Agent Monitor
CDS	Civil Defense Simultest
CGI	Combustible Gas Indicator
GA	Tabun
GB	Sarin
GD	Soman
H^+	Hydrogen ion
HD	Sulfur mustard
HN	Nitrogen mustard
L	Lewisite
LFL	Lower Flammable Limit
LCD	Liquid Crystal Diode
LEL	Lower Explosive Limit
MOS	Metal Oxide Semi-conductor
MSDS	Material Safety Data Sheet
mV/pH	millivolt per potential Hydrogen unit
NIOSH	National Institute of Occupational Safety and Health
OH^-	Hydroxide or hydroxyl ion
OSHA	Occupational Safety and Health Administration
PEL	Permissible Exposure Limit
pH	potential Hydrogen
SOP	Standard Operating Procedures
TWA	Time-Weighted Average
UEL	Upper Explosive Limit
UFL	Upper Flammable Limit
VX	Venom X: any number of chemical compounds (nerve agent)

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Overview

It is important to recognize that there is not a single general-purpose instrument. Instead, instruments that give complementary information must be used to get different views of the same picture. Choosing the right instrument is only the first step in detecting a hazardous material. Validity of the information must be ensured by maintaining equipment, performing a pre-measurement calibration check, noting factors in the sampling environment that may affect performance, using correct sampling techniques, and performing an end calibration check. By practicing with each piece of equipment and becoming thoroughly familiar with instrument operation, response personnel will be better able to gather data and interpret results quickly and accurately during an emergency situation.

Terminal Learning Objective

Upon completion of this module, the participant will be able to demonstrate the use and describe the purpose of selected detection equipment for response to chemical releases.

Enabling Objectives

Based on the information presented in the classroom and in the student guide, and when given an examination, the participant will be able to:

- Describe the purpose and use of detection and monitoring equipment.
- List the detection equipment available to response personnel.
- Identify limitations that must be considered when interpreting readings using various monitoring devices.
- Discuss the significance of action levels.

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Introduction

Airborne and liquid contaminants can present a significant threat to human health. Identification and quantification of these contaminants by monitoring is an essential component of a health and safety program at a spill site. Monitoring data is useful for:

- Assessing the health risks to the employees and response workers.
- Selecting personal protective equipment.
- Delineating areas where protection is needed.
- Determining actual or potential effects on the environment.
- Selecting actions to mitigate the hazards safely and effectively.
- Determining the effectiveness of decontamination activities.

Calibration

For an instrument to function properly in the field, it should be calibrated prior to use. Calibration is the process of adjusting the instrument read-out so that it corresponds to the actual concentration. Calibration involves checking the instrument with a known concentration of a gas or vapor to see that the instrument gives the proper response.

Direct-Reading Air Monitoring Instruments

Many hazards may be present when responding to hazardous materials spills. There are several types of instrumentation for detecting hazardous atmospheres.

Oxygen Indicators

Oxygen indicators are used to evaluate an atmosphere for oxygen content for respiratory purposes. Normal air is 20.8% oxygen. Generally, if the oxygen content decreases below 19.5% the atmosphere is considered to be oxygen deficient and special respiratory protection is needed. Some instruments require sufficient oxygen for operation. As an example, some combustible gas indicators do not give reliable results at oxygen concentrations below 14%.

Increased Risk of Combustion

Concentrations above 23% are considered oxygen-enriched and increase the risk of combustion. Also, the inherent safety approvals for instruments are for normal atmospheres and not for oxygen-enriched atmospheres.

Presence of Contaminants

A decrease in oxygen content can be due to the consumption of oxygen (by combustion or a reaction such as rusting) or the displacement of air by a chemical. If it is due to consumption, then the concern is the lack of oxygen. If it is due to displacement, then there is the additional hazard of something present that could be flammable or toxic.

Oxygen deficient atmospheres may occur in unventilated areas or may be due to terrain variations in cases where heavier-than-air vapors may collect. Most indicators have meters that display the oxygen concentration from 0 to 25%.

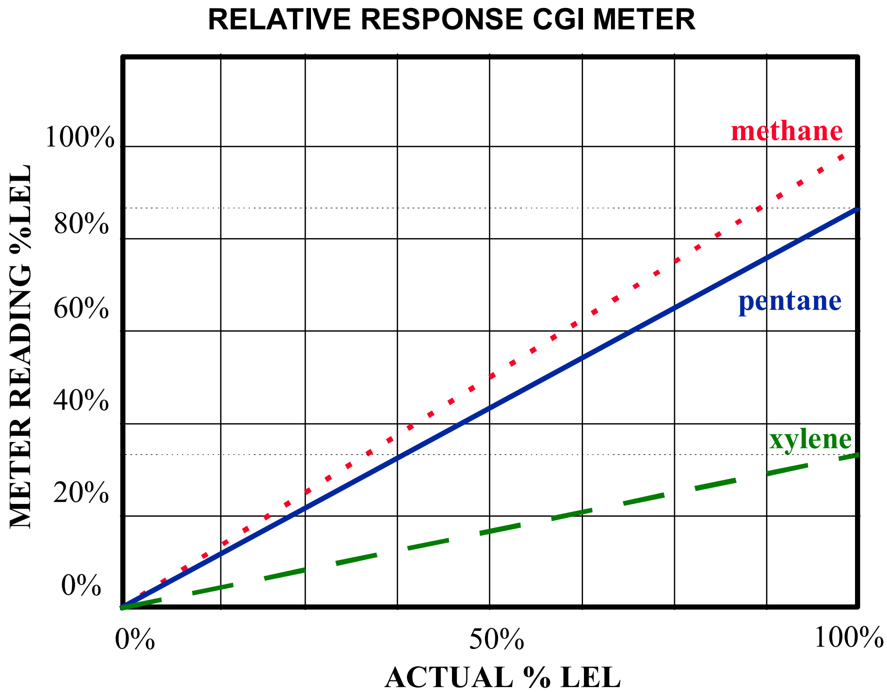
Combustible Gas Indicators

Combustible gas indicators (CGIs) measure the concentration of a flammable vapor or gas in air. These measurements indicate the percentage of the lower explosive limit (LEL) of the calibration gas.

The LEL (or LFL - lower flammable limit) of a combustible gas or vapor is the lowest concentration, by volume in air, which will explode, ignite, or burn when there is an ignition source. The upper explosive limit (UEL) is the maximum concentration; above the UEL there is insufficient oxygen to support combustion, so ignition is unlikely. Below the LEL there is insufficient fuel to support combustion. Concentrations between the LEL and the UEL are considered flammable and represent the flammable range of the material.

Limitations and Considerations

The readings of a combustible gas indicator are relative to the calibration gas. The readings, when measuring a different gas or vapor, may not show the actual percent of LEL. For example, most meters are calibrated for methane. If the gas being detected is xylene, the meter could be reading as low as 32% of LEL but the actual xylene concentration could be at the LEL. Please refer to the Relative Response CGI meter diagram on the next page.



Prudent practice if the gas or vapor is unknown is to take action whenever the meter reads more than 10% of LEL.

These instruments are intended for use only in normal oxygen atmospheres. Oxygen deficient atmospheres will produce lowered readings. Also, the safe guards that prevent the combustion source from igniting a flammable atmosphere are not designed to operate in an oxygen-enriched atmosphere.

Toxic Atmosphere Monitors

Along with oxygen concentration and flammable gases or vapors, there is a concern about chemicals present at toxic concentrations. Several functions must be performed to protect health and safety:

- Identify airborne concentration that could pose a toxic risk to response workers and the public.
- Evaluate the need for and type of personal protective equipment.
- Set up work zones or areas where contaminants are or are not present.

There are several different types of monitors that can be used for these functions.

Colorimetric Indicator Tubes (Detector Tubes)

Colorimetric indicator tubes such as those from Drager and MSA consist of a glass tube impregnated with an indicating chemical. The tube is connected to a piston like the Mine Safety Appliances (MSA) Model A, or a bellows-type pump like the Drager. A known volume of contaminated air is pulled at a pre-determined rate through the tube by the pump. The contaminant reacts with the indicator chemical in the tube, producing a change in color whose length is proportional to the contaminant concentration. Detector tubes are normally chemical-specific. There are different tubes for different gases.

Some manufacturers do produce tubes for groups of gases, such as aromatic hydrocarbons or alcohols. Concentration ranges on the tubes may be in the ppm or percent range. A preconditioning filter may precede the indicating chemical.

Limitations and Considerations

Detector tubes have the disadvantage of poor accuracy and precision. Manufacturers report some error factors of up to 50% for some tubes.

The chemical reactions involved in the use of the tubes can be affected by temperature. Cold weather slows the reactions and thus the response time. To reduce this problem it is recommended that the tubes be kept warm (for example, inside a coat pocket) until they are used if the measurement is done in cold weather. Hot temperatures increase the reaction and can cause a problem by discoloring the indicator when a contaminant is not present. This can happen even in unopened tubes. Therefore, the tubes should be stored at a moderate temperature or even refrigerated during storage.

An advantage that detector tubes have over some other instruments is that it is possible to select a tube that is specific to a chemical. However, some tubes will respond to interfering compounds. Fortunately, the manufacturers provide information with the tubes on interfering gases and vapors. The information includes the number of pump strokes needed, time for each pump stroke, interfering gases and vapors, effects of humidity and temperature, shelf life, and proper color change.

Interpretation of results can be a problem. Since the tube's length of color change indicates the contaminant concentration, the user must be able to see the end of the stain.

Some stains are diffused and are not clear-cut; others may have an uneven end-point. When in doubt, use the highest value that would be obtained from reading the different aspects of the tube. The total volume to be drawn through the tube varies with the tubes. The volume needed is specified, as the number of pump strokes needed; i.e., the number of times the piston or bellows is manipulated. Also, the air does not instantaneously go through the tube. It may take 1 to 2 minutes for each volume (stroke) to be completely drawn. Therefore, sampling times can vary from 1 to 30 minutes per tube. This can make the use of detector tubes time-consuming.

Due to these many considerations, it is very important to read the instructions that are provided with, and are specific to, a set of tubes.

While there are many limitations and considerations for using detector tubes, detector tubes allow the versatility of being able to measure a wide range of chemicals with a single pump. Also, there are some chemicals for which detector tubes are the only direct-reading indicators.

Specific Chemical Monitors

There are several gas monitors that utilize electrochemical cells or metal oxide semi-conductors (MOS) for detecting specific chemicals. MOS detectors change conductivity when exposed to certain gases or vapors. They can be designed to respond to a large group of chemicals or to a specific chemical. The most common monitors are used to detect carbon monoxide or hydrogen sulfide, but there are also monitors available for hydrogen cyanide, ammonia, and chlorine. They are more accurate than detector tubes, but there are only about a dozen different chemicals they can monitor.

Direct Reading Liquid Monitoring Equipment

Characterization of liquid requires different methods than air monitoring. Generally the hazards of liquid monitoring are higher than with air monitoring. This is due to the need for direct contact with the liquid in question by the test equipment.

Test Kits

The simplest liquid monitoring is done with test kits that use test papers that change color in the presence of a specific hazard or a hazardous characteristic. There are test papers for acids and bases (pH paper), oxidizers and peroxides, and sulfides. Test kits are also available to characterize the concentrations of chlorinated compounds, including polychlorinated biphenyls (PCBs).

pH Meters

The pH meter is used to measure the hydrogen ion activity of water. The observed range of pH values runs from 0 to 14 pH units with 7 being neutral. The pH of most natural waters is within the range of 4.5 to 9. The majority of waters are slightly basic (pH greater than 7) because of the presence of carbonates and bicarbonates. The pH of most drinking water runs from 6 to 9.5. A solution is hazardous if the pH is less then 2 or greater than 12.

Presence of Contaminants

The pH electrode is relatively free from interference from color, turbidity, colloidal matter, oxidants, reductants, or high alkalinity. Temperature exerts significant effects on pH measurement. The effect of temperature can be overcome by use of the temperature compensation adjustment provided on most pH meters. Prudent practice is to record the temperature of a sample whenever pH is recorded.

Theory

The pH meter measures an electrical potential from a standard glass electrode and a reference electrode. Some meters use a combination electrode with both the glass and reference electrodes housed in the same tube. The glass-reference electrode pair produces a change of 59.1 mV/pH unit at 25°C. The pH of the solution refers to its hydrogen ion activity and is expressed as the logarithm of the reciprocal of the hydrogen ion activity in moles per liter at a given temperature.

Calibration

The pH meter must be calibrated before each use. The electrodes must be stored wet or damp and must have been wet for more then 24 hours before calibration. Calibration must be done with two standard buffer solutions, one neutral or pH 7.0 and one of higher or lower pH. The most common buffers are 7.0, 4.0, and 9.0 at 25°C. Because buffer solutions deteriorate as a result of mold growth or contamination, prepare fresh as needed in the field from pre-packaged powders and distilled water.

Limitations

The precision and accuracy attainable with a given pH meter will depend on the type and condition of the unit and the care used in calibration. Guard against possible erratic results arising from mechanical or electrical failures such as weak batteries, damaged or dry electrodes, or plugged or fouling of the electrodes with oily or solid materials. Under field conditions, report pH values to the nearest 0.1 pH unit.

Application of Detection Devices

It is essential that response personnel understand how to use the information obtained from detection devices. This requires an understanding of operation, limitations, and proper application of each device. The following basic rules should always be applied.

Use the Appropriate Instrument

Response personnel should not attempt to use a device that:

- Does not have the capability to detect the substance of concern.
- Cannot measure the material at the concentration of interest.
- Will not operate properly under the conditions of use.

For example, an odor of gasoline is reported in a sanitary sewer. The primary hazard is explosive vapor buildup within the sewer system. The appropriate instrument for measuring the hazard is the % LEL CGI, preferably a combination meter that also detects oxygen deficiency. It would be inappropriate to call for a carbon monoxide or hydrogen sulfide sensor. It would also be inappropriate to use a CGI that measures in ppm equivalents. Furthermore, if the oxygen sensor shows a concentration of less than 10% oxygen within the sewer, the CGI will not operate properly. The result will be a false negative reading.

A Zero Reading Is Not Evidence of Absence

If a device does not produce a reading, this does not mean that contamination is absent. The device used may not be capable of detecting the type or concentration of contaminant present. For this reason, multiple types of air monitoring instruments should be used to confirm the presence or absence of contamination.

Zero Reading

Using the scenario of gasoline in the sewer, suppose that there is a sufficient concentration of oxygen in the sewer to use a CGI. Does a reading of 0% LEL prove that no gasoline is present? Not at all. If the meter is working properly, such a reading indicates that there are no gases or vapors present in sufficient concentration to give a reading above 0%. To determine if low concentrations of gasoline vapors are present, it is necessary to use a device that measures in ppm equivalents for petroleum hydrocarbons or gasoline.

Assume Multiple Hazards

Response personnel may focus on what is perceived to be the primary hazard of a situation and forget that other hazards may also be present. Additional instruments can be used to rule out other potential hazards. For example, if there is 0% LEL and 20.8% oxygen in a sewer vault, this does not mean that the sewer vault is safe to enter. Other hazards must be considered as well. A petroleum vapor tube detector tube reading may indicate the presence of hydrocarbons that did not register on the CGI. The vault should be assessed for the presence of other materials, such as hydrogen sulfide gas, using the appropriate sensor or detector tube.

Establish Action Levels

Action levels are readings or responses to known or unknown hazards that trigger some action. The action taken may include evacuating unprotected or unnecessary personnel, watching meter readings more closely, upgrading levels of personal protection, or leaving the area altogether. These must be based on departmental Standard Operating Procedures (SOPs). The action levels discussed below are accepted by most agencies.

% LEL Action Levels

The CGI is a safety meter; it is intended to tell the user whether or not it is safe to be in a particular area. A meter reading of 100% LEL is obviously unsafe. But at what percent of the LEL reading should the user become concerned? For known or unknown materials the safe level should be no more than half of the LEL. This value is considered the action level.

For example, the LEL for methane is a concentration of 5% by volume in air; 10% of this value is 0.5%, a concentration which, by definition, would be considered hazardous. Under the guideline, the measured concentration of methane should not exceed 0.25% (half of 0.5%).

Other Action Levels

Action levels have been defined by the Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists for workplace exposures to many commonly encountered chemicals. The 8-hour maximum exposure levels can be used as action levels in emergency response. For safe areas the concentration should not be more than 50% of the PEL-TWA. Measurements can establish the appropriate size of the Hot Zone and safe areas for unprotected personnel.

When the contaminant is unknown, responders must rely on the instruments at hand to provide a general indication of the relative health risks that may be present. A CGI reading of 1% LEL should indicate an action level from a health standpoint. The 1% reading suggests that there are at least 10,000 ppm (and possibly much more) of a combustible gas is present. From an exposure perspective has the PEL been reached or exceeded? Similarly, a 0.1% decrease in oxygen concentration may represent a concentration of an unknown of 5,000 ppm. When such readings are obtained, the area should be considered hazardous, requiring appropriate respiratory and skin protection for entry.

Sample Employer's % LEL Policy

- Employer will issue work permits when the % LEL is from 0-10% LEL.
- When the LEL exceeds 10%, special approval is required in order for a work permit to be issued.
- For all confined space entry permits, a 0% LEL is required.
- The Emergency Response Teams can respond to varying % LEL readings when hazards have been identified and risks have been assessed. Consideration must be given to the:
  - ⇒ Size (quantity and physical area) of the spill.
  - ⇒ Types of material.
  - ⇒ Impact on other areas.
  - ⇒ Equipment available.
  - ⇒ Training.

Members of emergency response teams should consult at least three references to verify information such as LEL, physical properties of the spilled material, and PPE needed to respond safely. Example references that may be available to response personnel include:

- MSDSs.
- Emergency Response Guide.
- NIOSH Pocket Guide.
- Firefighters' Guide to Hazardous Materials.

- Firefighters' Hazardous Materials Reference Book.
- Firefighters' Handbook to Hazardous Materials.

Detection of Chemical Warfare Agents

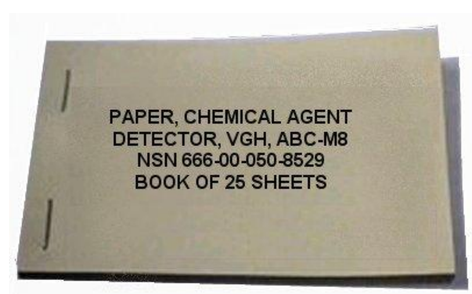
M9 Chemical Detection Paper

The M9 Chemical Agent Detector Paper was developed for the U.S. military to enable soldiers to detect nerve agents including VX, G agents (tabun, sarin, soman) and mustard H gases. The adhesive-backed paper is placed on personnel and equipment to identify the presence of liquid chemical agents and aerosols. It will turn pink, red, reddish-brown, or red-purple when exposed to liquid nerve agents and blister agents, but it does not identify the specific agent.

The M9 paper can be attached to workers on the wrist, upper arm, and ankle while working in potentially contaminated areas. It can also be attached to large pieces of equipment to monitor for nerve and blister agents. When attached to equipment, it must be placed in an area free from petroleum products because petroleum products will cause M9 paper to give a false-positive color change. The results of the M9 paper should be confirmed with the M256 kit.

Warning: The M9 detector paper dye is a suspected human carcinogen. Always wear protective gloves when touching M9 detector paper. Do not place M9 detector paper into or near your mouth or on your skin. M9 detector paper will not detect chemical agent vapors; it is used to detect liquids and aerosols only. M9 paper can give false positive results when it comes into contact with brake fluid, gasoline, insect repellent, or antifreeze. Any positive results should be confirmed using M8 chemical agent detector paper and the M256 chemical agent detector kit.

M8 Paper-Chemical Agent Detector Paper



M8 paper is a chemical agent detector and identifier. It provides the means to perform a quick identification of liquid (only) nerve and blister agents. One booklet contains 25 perforated sheets. The paper changes to a specific color to indicate the presence of G-series nerve agents, H-series blister agents, and V-series nerve agents. Color codes are located inside the front cover of the booklet.

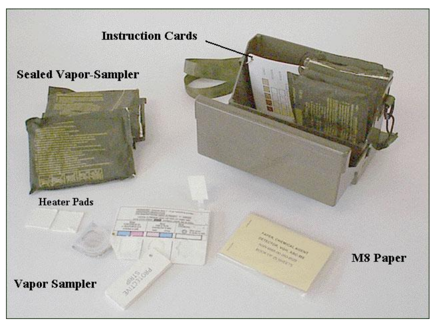
When a sheet of M8 paper contacts a liquid nerve or blister agent, the agent reacts with chemicals in the paper to produce agent-specific color changes. There are three indicator dyes suspended in the paper matrix. The responder blots the paper on a suspected liquid agent and observes the paper for a color change (liquid agent absorption). The chemical reaction between the M8 paper and chemical agent creates a pH-dependent color change on the M8 paper. V-series nerve agents turn the M8 paper dark green, G-series nerve agents turn yellow, and blister agents (H-series) turn red.

There are limitations to using M8 paper. Responders using M8 paper need to be aware of the possibility of a false positive result when they are performing agent identification tests. Chemicals such as xylene, methanol, and ethanol, to name a few, may cause false positive readings. To use M8 paper, blot (do not rub) the M8 paper on the suspected liquid with a gloved hand; if desired, responders may choose to place the M8 paper on the end of a stick or another object.

M256A1 Chemical Agent Detector Kit

The M256 Chemical Agent Detector Kit is small, easy to carry, lightweight, and comes with complete instructions. It is a miniature chemistry laboratory capable of detecting the presence of nerve, blood, blister, and lewisite agent vapors within 20 minutes.

It does not detect choking agents (i.e., chloropicrin (PS), chlorine (Cl), phosgene (CG), or diphosgene (DP).



It detects the presence of dangerous concentrations of these toxic agents by color-changing chemical reactions. Each kit consists of 12 disposable sampler-detectors, one booklet of M8 paper, and a set of instruction cards attached by a lanyard to a plastic carrying case.

The manufacturer makes the case from molded, high-impact plastic, which includes a nylon-carrying strap and a nylon belt attachment. Each sampler-detector contains a square, impregnated spot for blister agents, a circular test spot for blood agents, a star test spot for nerve agents, and a lewisite-detecting tablet and rubbing tab.

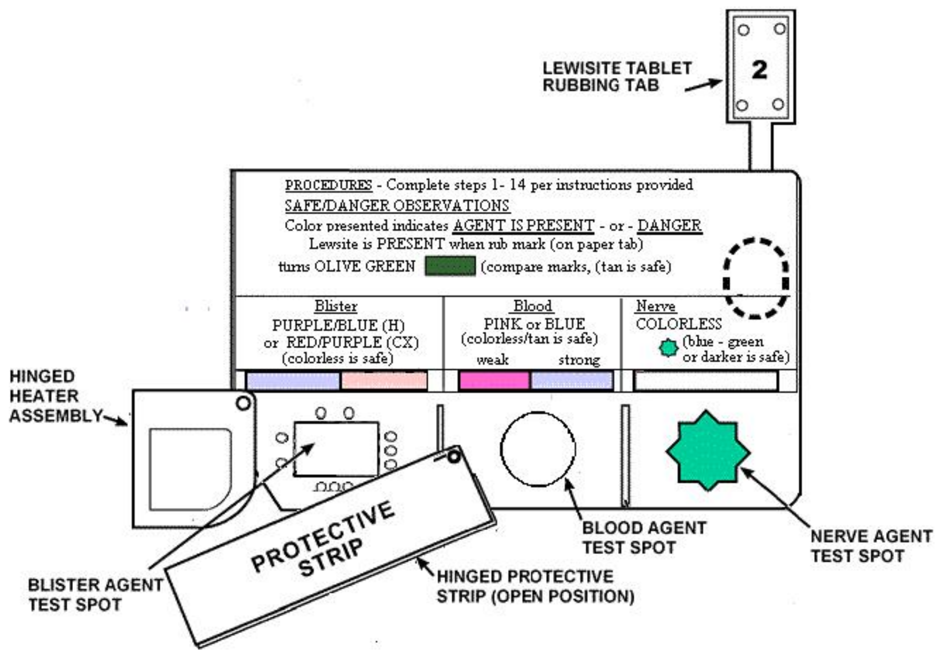
The test spots are made of standard laboratory filter paper. There are eight glass ampoules, six containing reagents for testing and two in an attached chemical heater.

When the user crushes the ampoules between his or her fingers, formed channels in the plastic sheets direct the flow of liquid reagent to wet the test spots. Each test spot or detecting tablet develops a distinctive color that indicates whether a chemical agent is or is not present in the air. Any type of mustard is also detectable as long as vapor is present.

Each sampler-detector contains about 2.6 milligrams of mercuric cyanide; therefore, used or expired kits must be disposed of as a hazardous waste in accordance with local procedures.

To check the kit for serviceability, the user must check for rips, tears, or holes, and he or she must ensure that the heater tabs and sampler ampoules are intact (not crushed). Be sure to check the discard date on the kit before using it.

256 Chemical Agent Detection Kit Diagram



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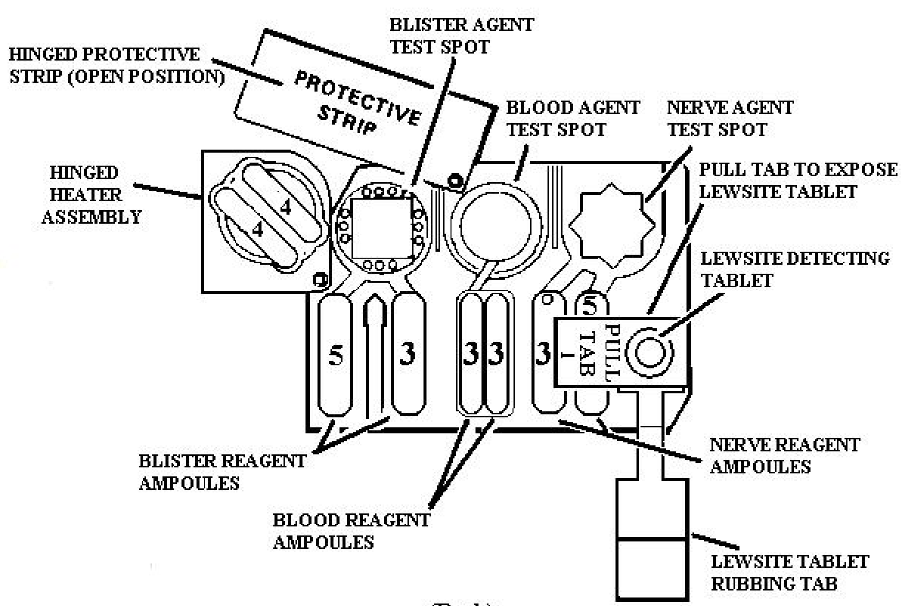


(Back)

The carrying case also has attachments and straps that should not be missing or damaged. Because ultra-violet rays from the sun may produce false readings, do not hold the sampler detector in direct sunlight while exposing test spots.

MSA Chemical Warfare Agent Detector Tubes

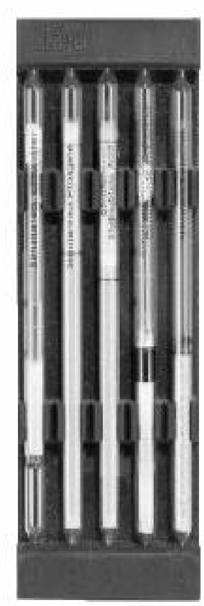
Mine Safety Appliances (MSA) manufactures colorimetric detector tubes to detect nerve, blister, choking, and blood agents. Detector tubes are glass ampoules approximately five (5) inches long that are filled with reagent-impregnated granular solids. The ends of the detector tube ampoules are broken off and the tube is inserted into a suction pump. The user then draws air through the tube for a specified number of pump strokes. Once the series of pump strokes is completed, the user interprets the results. Quantitative tubes have a direct reading scale on the tube with the length of the color stain indicating the quantity of contaminant detected. Qualitative tubes use length and intensity of stain to indicate the presence of the material.

MSA produces tubes to detect more than 120 gases and vapors. They also produce five tubes specifically designed to detect chemical warfare agents. The instruction sheet included in each box of tubes describes the chemical reaction, color change, and interpretation of results. The step-by-step sampling procedure for each tube is also presented on the instruction sheet.

MSA detector tubes are advertised as being capable of detecting low concentrations of chemical warfare agent vapors. The HD detection tubes are designed to detect concentrations down to 1 mg/m^3 using 50 pump strokes. The phosphoric acid ester (PAE) nerve agent detector tubes are capable of detecting sarin (GB), soman (GD), VX, GP, tabun (GA), and GF in air to approximately 0.01 mg/m^3 using ten pump strokes.

Drager Civil Defense Simultest I & V (CDS) Kit

The Drager Civil Defense Simultest Kits are designed to produce immediate and accurate detection of eight chemicals, including nerve, blood, lung, nose, and irritating agents. The Drager CDS Kits use specially developed colorimetric tubes bundled into a five-tube adapter. The adapter orifice is inserted into the pump and air is drawn through all tubes simultaneously.



Colorimetric tubes are glass ampoules that contain a chemical preparation that reacts with a gas or vapor by changing color. Most colorimetric tubes are scale tubes and the length-of-stain discoloration indicates the concentration of the measured substance. The printed scale allows direct reading of the concentration. Colorimetric tubes and gas detector pumps are designed and calibrated as a unit.

Civil Defense Simultest Set I is a five-tube set used to detect thioether (S-mustard), phosgene, hydrocyanic acid, organic arsenic compounds and arsine (Lewisite), and organic basic nitrogen compounds (nitrogen mustard). Civil Defense Simultest Set V is a five-tube set used to detect cyanogens chloride, S-mustard, phosgene, chlorine, and phosphoric acid ester (nerve agents; e.g. tabun, sarin, and soman).

The CDS kit comes in a portable carrying case that contains the tube opener, Accuro hand pump, extension hose, and laminated instructions and charts for interpretation of results. The hand pump comes with a count meter for keeping count of the number of pumpstrokes. Each tube in the set is designed to detect a particular agent and has its own set of instructions.

Chemical Agent Monitor (CAM)

During cleanup operations that involve persistent chemical warfare agents, personnel responsible for monitoring and sampling must be able to detect and quantify those agents quickly. Persistent chemical warfare agents (i.e., mustard and VX) have low volatility and evaporate slowly. They can contaminate objects, buildings, and terrain as well as the air.

The cleanup operations may expose disaster-recovery workers to lethal concentrations of these agents if careful monitoring is not conducted. Unfortunately, the first indicators of chemical exposure are usually the symptoms exhibited by the victims. The chemical agent monitor (CAM) is an effective hand-held electronic instrument that performs this task well.

The CAM is designed to indicate the presence of nerve (G mode) or blister (H mode) agent vapors down to the lowest hazard that could affect people over a short period. The instrument indicates the relative vapor concentration level on a liquid crystal display (LCD), which illuminates from behind for nighttime operations. It detects vapors of chemical agents by sensing molecular ions of specific mobility (time of flight) and uses timing and microprocessor techniques to reject interferences.

The monitor detects and discriminates between vapors of nerve and mustard agents. The CAM consists of a drift tube, signal processor, molecular sieve, membrane, confidence tester, dust filters, and a battery pack.

Workers use the CAM to identify clean areas and locate contamination on personnel, equipment, buildings, and terrain. The monitor requires one internal 6-volt, lithium-sulfur dioxide battery that provides at least ten hours of operation. Battery life varies with frequency of use and temperature.

The CAM is not an area detector, but rather a point source monitor. It can become saturated (overloaded) if not pulled away from the source immediately upon obtaining a reading on the LCD.

The CAM does not emit an audible alarm on detection of H or G series agents; an improved version, the ICAM, possesses alarm capability. When properly used, the CAM is an effective tool to monitor for the presence of nerve or blister agents in vapor form.

APD 2000

Environmental Technologies Group Inc. (ETG) manufactures the APD2000 detectors. The detector is a lightweight (approximately 6 pounds, including the batteries), handheld, portable detector designed for surveying the environment to identify specific chemical warfare (CW) agents and irritants.

It contains 10-millicuries of Nickel 63, a radioactive source. The user can operate the detector in CW or irritant mode. The APD2000 detects nerve and blister agents simultaneously in its CW mode. It also has data logging features (a purchased option) to record monitoring events.

The APD2000 employs ion mobility spectrometry (IMS) detection techniques. Sample air passes through the heated membrane and then a motor draws it into the cell assembly. The radiation source ionizes the air molecules. The resulting ions move down the drift tube, where they become separated according to their mass and mobility toward the collector electrode. Each ion produces an electronic signature, based on the time required to reach the collector electrode.

The APD2000 alarms if the sample signal matches the required signature criteria, which shows reference level readings and the identity of the substance detected. The reference level is a value between zero and 100, which identifies the specific CW agent, or the class of CW agent, that causes the detector to alarm. Larger numbers indicate the presence of a higher concentration of vapor. The numeric values located in the lower, right-hand portion of the LCD are relative concentration levels indicating low (26 to 50), medium (51 to 75), and high (76 to 100), respectively, and will trigger the audio alarm.

Response values below 25 indicate the presence of a substance of low concentration levels below the alarm set point. The audio alarm will not sound when below the threshold set point.

The reference class for this detector response can be either nerve or blister, with or without a specific agent (GA, GB, GD, VX, HD, HN or L) identified. This feature, despite occasional mislabels, distinguishes this detector from others tested thus far.

The detector also contains a back-flush pump that reverses the sample flow path to protect the cell assembly from gross contamination. Back-flush mode is activated when the detector displays a HIGH (76 to 100) concentration detection.

The APD2000 detector derives power from many different sources, including six standard or rechargeable C-cell batteries, an AC adapter, or a 9 to 18 volt DC supply. Six C-cell batteries can sustain approximately seven hours of operation at ambient temperature.

The APD2000 operating specifications give the operational temperature range from -22^{o}F to 126^{o}F (-30^{o}C to +52^{o}C), and the relative humidity range from zero to 95 percent. Battery life decreases significantly at lower temperatures.

<table>
<tr><th>Sensitivity</th><th>Parts Per Billion (ppb)</th><th>Time (Seconds) Required</th></tr>
<tr><td>V</td><td>4</td><td>30</td></tr>
<tr><td>G</td><td>15</td><td>30</td></tr>
<tr><td>H</td><td>300</td><td>15</td></tr>
<tr><td>L</td><td>200</td><td>15</td></tr>
<tr><td colspan="3">High concentrations of these agents will cause APD to alarm within 10 seconds</td></tr>
<tr><td>Operator service</td><td colspan="2">5 min per 24 hours of operations</td></tr>
</table>

Summary

Chemical detection requires a number of different equipment pieces, ranging from simple papers to hand-held/hand-manipulated electronic devices, wet chemistry systems, and sophisticated laboratory instruments.

Chemical agent detection and identification requires the knowledge of signs and symptoms coupled with simple detection equipment in order to identify the unknown agent. Without the aid of chemical detection equipment, responders cannot detect the presence of an agent. No one chemical agent kit detects all agents.

Because there are fewer detectors and identification methods for biological materials, detecting and identifying biological agents will likely take place in local, state, or federal laboratories.

Radiation detection devices are easy to use and are common instruments. Be sure to have the right type of detector – alpha, beta, or gamma – to do the job.

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Review Questions

1. List some of the reasons monitoring is an essential component of a health and safety program.

2. Give some examples of detection equipment that could be available to spill response personnel.

3. In using a CGI, what are the device limitations?

4. Are there any special considerations that you must be aware of in using a CGI?

5. In using any monitoring device, explain why an understanding of the device limitations and considerations is important.

6. What is an action level and how are action levels determined?

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